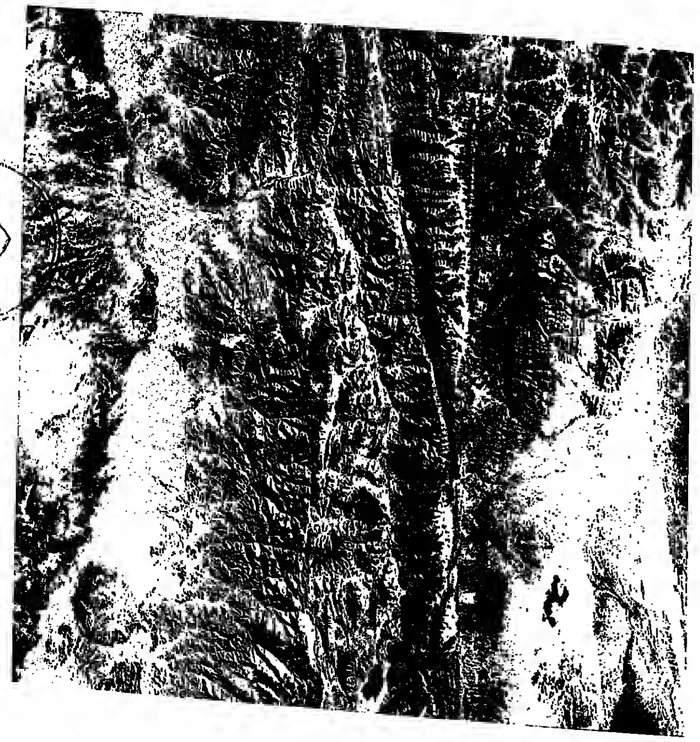


EOS
Transactions, American Geophysical Union
Vol. 64 No. 32 August 9, 1983

EOS, Transactions, American Geophysical Union Vol. 64, No. 32, Pages 497–504 August 9, 19

Biological Transformation of Organic Pollutants in Groundwater

John T. Wilson and James F. McNabb

R.S. Kerr Environmental Research Laboratory, U.S. Environmental Protection Agency, Ada, Oklahoma 74820

Recent investigations have discovered surprisingly high numbers of microorganisms in shallow water-table aquifers. Evidence is accumulating that these microorganisms may, under certain circumstances, transform many of the organic pollutants that enter the subsurface environment. These transformations can lead to total destruction of the pollutant or to the production of new organic pollutants.

Introduction

The phenomenal expansion of the chemical industry in this century, and particularly since World War II, has brought us many blessings and several new problems. Among these is widespread pollution of groundwater in industrial areas with organic contaminants and the growing pollution of groundwater in agricultural areas with pesticides and herbicides. The role played by microorganisms in the destruction of organic contaminants in surface water has long been appreciated. However, the importance of subsurface microorganisms in controlling the quality of groundwater has only recently become apparent.

Groundwater is Part of the Biosphere

In early studies of the numbers of microbes in soils, the microorganisms were counted by spreading dilutions of subsurface material on a culture medium and counting the colonies that developed. Because very few colonies developed from samples of soil taken below the root zone, early microbiologists concluded that this region of the earth was essentially devoid of life [*Waksman*, 1916]. As a result, an understanding of the true size and importance of the populations of organisms that occur naturally in groundwater was delayed. Recently, techniques have been developed that allow microbiologists to study all of the microbes in the subsurface and not just those that could grow on nutrient agar or on some similar growth medium.

Special staining procedures that distinguish cellular material from noncellular particles of the same size and shape have been adapted to subsurface material [*Ghiorse and Balkwill*, 1983]. After staining, the microbes can be counted directly in samples of subsurface material with a microscope. The technique has been applied to core material from several shallow water-table aquifers and associated material from the vadose zone. These cores were obtained by using special procedures developed to provide uncontaminated subsurface samples [*Wilson et al.*, 1983*b*]. The numbers of organisms were surprisingly high (Table 1). Numbers did not decline drastically with depth, and there was surprising uniformity of numbers at different seasons and in material from replicate bore holes at the same site.

The population density of organisms in the cores was comparable with the density of bacteria in nutrient-rich lakes (see *Pedros-Alio and Brock*, 1982). In fact, the total biomass in regions below the root zone in North America is probably much higher than the bacterial biomass in the rivers and lakes of our continent. Shallow water-table aquifers and associated regions of the vadose zone, therefore, are an important microbial habitat, which until recently had been virtually ignored by microbiologists.

The groundwater microbes were studied by electron microscopy to learn something of their structure and taxonomy. When fine-grained subsurface material was examined, several morphological forms of bacteria were seen [*Ghiorse and Balkwill*, 1983; *Wilson et al.*, 1983*b*]. There was little evidence of yeasts or other fungi, protozoa, or higher animals. This makes the assemblage of bacteria in these environments unique, because organisms that are important scavengers and predators in other natural systems, such as protozoa, are missing. Sands and gravels in river valleys may contain a wide variety of higher organisms [*Danielpol*, 1976]. Coarse material in upland landscapes is yet to be examined.

To confirm the results of the microscopic examinations, the biomass of organisms in the core material was also estimated by extracting and quantifying certain biochemical compounds that are usually restricted to living organisms [*White et al.*, 1983]. The biochemical analyses for biomass, in general, showed good agreement with expected values based on cell numbers. Also in agreement with the direct count, the biochemical characterization failed to detect any of several biochemicals that are found in protozoa, fungi, or higher animals, but not in bacteria.

The biochemical characterization of subsurface material is potentially a very powerful tool. Certain physiological groups of bacteria, such as the sulfate reducers or the methane bacteria, can be detected by the presence of cellular constituents that are restricted in that group. On the other hand, the general nutritional state of the entire biological community can often be inferred from the ratio of the quantities of certain biochemicals found in most bacteria.

TABLE 1. Numbers of Organisms in the Subsurface Environment

Site	Depth to Water Table, m	Subsoil§	Just Above Water Table§	Just Below Water Table§
Lula, Okla.*	3.6			
February 1981		6.8	3.1	6.8
June 1981		9.8	3.7	3.4
Fort Polk, La.†				
Borehole 6B	6.1	3.4	1.3	3.0
Borehole 7	5.0	7.0	1.3	9.8
Conroe, Texas‡	6.1	0.5	0.3	0.6
Long Island, N.Y.‡				
	6.0	—	—	38
	3.0	170	—	—
Pickett, Okla.†	5.0	—	—	5.2

*Wilson et al. [1983].
†Ghiorse and Balkwill [1982].
‡W. G. Ghiorse (personal communication, 1982).
§In millions per gram dry material.

TABLE 2. Prospect of Biotransformation of Selected Organic Pollutants in Water-Table Aquifers

Class of Compounds	Aerobic Water, Concentration of Pollutant, µg/l >100	Aerobic Water, Concentration of Pollutant, µg/l <10	Anaerobic Water
Halogenated Aliphatic Hydrocarbons			
Trichloroethylene	none	none	possible*
Tetrachloroethylene	none	none	possible*
1,1,1-Trichloroethane	none	none	possible*
Carbon Tetrachloride	none	none	possible*
Chloroform	none	none	possible*
Methylene Chloride	possible	improbable	possible
1,2-Dichloroethane	possible	improbable	possible
Brominated methanes	improbable	improbable	probable
Chlorobenzenes			
Chlorobenzene	probable	possible	none
1,3-Dichlorobenzene	probable	possible	none
1,4-Dichlorobenzene	probable	possible	none
1,2-Dichlorobenzene	improbable	improbable	none
Alkylbenzenes			
Benzene	probable	possible	none
Toluene	probable	possible	none
Dimethylbenzenes	probable	possible	none
Styrene	probable	possible	none
Phenol and Alkyl Phenols	probable	probable	probable†
Chlorophenols	probable	possible	possible
Aliphatic Hydrocarbons	probable	possible	none
Polynuclear Aromatic Hydrocarbons			
Two and three rings	possible	possible	none
Four or more rings	improbable	improbable	none

*Possible, probably incomplete.
†Probable, at high concentration.

Biotransformations of Organic Pollutants

Organisms in the deeper subsurface environment can transform many important organic pollutants. The rate of transformation is limited by the numbers and activity of the microorganisms, while the extent of transformation is most frequently limited by some requirement for metabolism such as oxygen, pH buffering capacity, or mineral nutrients.

As a result, the biological fate of a particular class of organic pollutant is controlled by the geochemical properties of the subsurface environment. For example, *Wilson et al.* [1983*a*] and *Wilson et al.* [1983*b*] found no evidence for biological degradation of chlorinated aliphatic hydrocarbons in three shallow aerobic aquifers. On the other hand, *Parsons* [1983] showed that many of these compounds could be transformed in anaerobic subsurface material. In muck soil from Florida, carbon tetrachloride was transformed to chloroform. Similarly, tetrachloroethylene was transformed to trichloroethylene, then to all three dichloroethylenes and perhaps to vinyl chloride. In a study of the fate of halogenated hydrocarbons in treated municipal wastewater after injection of wastewater into an aquifer, *Bouwer et al.* [1981] found that chloroform and several other halogenated methanes were transformed readily in the anaerobic water in the aquifer, and tri- and tetrachloroethylene disappeared at a somewhat slower rate.

The geochemical properties of the subsurface environment also limit the degradation of organic pollutants that are natural products, as opposed to synthetic industrial chemicals. *Ehrlich et al.* [1982] studied the fate of creosote waste in a contaminated aquifer and found that many phenolic compounds in the waste were being degraded to carbon dioxide and methane by an anaerobic consortium of bacteria in the aquifer. However, they found no evidence that polynuclear aromatic hydrocarbons such as naphthalene were being degraded under anaerobic conditions in the aquifer.

Predicting Degradation of Organic Pollutants

The relationship between the concentration of a pollutant and its fate is complex. At reasonably high concentrations (>100 µg/l) utilization of a pollutant can provide an ecological advantage, resulting in an increase in the numbers of microbes that metabolize the organic pollutant. At concentrations less than 10 µg/l, use of the pollutant usually does not provide enough of an advantage to lead to enrichment of active organisms. At concentrations greater than 1,000–10,000 µg/l, metabolism of the pollutant can entirely deplete oxygen or other metabolic requirements in the groundwater.

As a result, compounds that usually are considered degradable may not be transformed by the subsurface microorganisms if the compound is present at low concentrations. Similarly, compounds present at high concentration may be only partially degraded when oxygen is entirely depleted and can only be degraded further after dispersion or other physical processes mix the contaminated water with oxygenated water.

Table 2 presents the authors' opinions concerning the prospects for biotransformation of several important classes of organic pollutants in groundwater. These predictions are based on a cautious extrapolation from the behavior of these compounds in other natural systems and on our admittedly limited experience with their behavior in the subsurface environment. The research effort in this area is expanding rapidly. As our knowledge grows, microbiology should become a useful complement to the earth sciences in our search for a better understanding of the behavior of organic contaminants in the subsurface environment.

Acknowledgments

Although the research described in this article has been funded in part by the United States Environmental Protection Agency through Cooperative Agreement CR806931 to the National Center for Ground Water Research and through in-house research programs at the Robert S. Kerr Environmental Research Laboratory, it has not been subjected to Agency review and therefore does not necessarily reflect the views of the Agency and no official endorsement should be inferred.

References

Bouwer, E. J., B. E. Rittmann, and P. L. McCarty, Anaerobic degradation of halogenated 1- and 2-carbon organic compounds, *Environ. Sci. Tech. 15*, 596–599, 1981.

Danielpol, D. L., The distribution of the fauna in the interstitial habitats of riverine sediments of the Danube and Priesting (Austria), *Int. J. Speleol. 8*, 23–51, 1976.

Ehrlich, G. G., D. F. Goerlitz, E. M. Godsy, and M. F. Hult, Degradation of phenolic contaminants in ground water by Anaerobic bacteria: St. Louis Park, Minnesota, *Ground Water, 20*, 703–710, 1982.

Ghiorse, W. C., and D. L. Balkwill, Enumeration and morphological characterization of bacteria indigenous to subsurface environments, *Dev. Ind. Microbiol., 24*, in press, 1983.

Parsons, F., Transformation of chlorinated organic solvents in ground water environments in South Florida, paper to be presented at the ACS Environmental Chemistry Symposium on Organic Contaminant Behavior in the Subsurface Environment, American Chemical Society, Washington, D.C., Aug. 28 to Sept. 2, 1983.

Pedros-Alio, C., and T. D. Brock, Assessing biomass and production of bacteria in eutrophic Lake Mendota, Wisconsin, *Appl. Environ. Microbiol., 14*, 203–218, 1982.

Waksman, S. A., Bacterial numbers in soil, at different depths, and in different seasons of the year, *Soil Sci. 1*, 363–380, 1916.

White, D. C., G. A. Smith, M. J. Gehron, J. H. Parker, R. H. Findlay, R. F. Martz, and H. L. Fredrickson, The ground water aquifer microbiota: Biomass, community structure, and nutritional status, *Dev. Ind. Microbiol., 24*, in press, 1983.

Wilson, J. T., J. F. McNabb, B. H. Wilson, and M. J. Noonan, Biotransformation of selected organic pollutants in ground water, *Dev. Ind. Microbiol., 24*, in press, 1983*a*.

Wilson, J. T., J. F. McNabb, D. L. Balkwill, and W. C. Ghiorse, Enumeration and characterization of bacteria indigenous to a shallow water-table aquifer, *Ground Water, 21*, 134–142, 1983*b*.

John T. Wilson is a soil microbiologist and microbial ecologist who has been actively involved in research dealing with biodegradation of organic contaminants in groundwater since receiving his Ph.D. from Cornell University in 1978. He is currently a microbiologist with the U.S. Environmental Protection Agency's Ground Water Environmental Research Branch at the Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma, where his research is concentrated on developing a kinetic description of the biotransformation of organic contaminants in the subsurface by indigenous organisms.

James F. McNabb has been a microbiologist with the Ground Water Research Branch of U.S. EPA's Robert S. Kerr Environmental Research Laboratory in Ada, Oklahoma, since the late 1960's. He has degrees from Texas Technological University and the University of Oklahoma and received in 1978 a Fulbright research grant to conduct groundwater research in New Zealand. His research interests involve many aspects of groundwater microbiology including the development of methods for the study of subsurface microbial activity.

News

Borehole Sensor Records Quake

A permanent, self-contained borehole seismometer placed at 44°N, 160°E in the northwest Pacific on September 11, 1982, recorded the May 26 Japan quake while being serviced by the R/V *Kana Keoki*. The signal was recorded digitally (100 samples per second) and is unclipped. Data are well above noise level from 0.03 Hz to over 40 Hz, a frequency span of more than 10 octaves, on all three orthogonal seismic components (4.5 Hz geophones). The 30 sec signals are shear and surface waves recorded 84 dB below the peak response of the geophones.

The instrument, placed by Hawaii Institute of Geophysics (HIG) scientists working from the D/V *Glomar Challenger* (DSDP Leg 88), also contains temperature and tilt sensors. The tilt sensors also recorded the quake. The seismometer is 20 m into basalt at the bottom of a 380 m hole in 5467 m of water. The noise levels are very low (6.4 nm²/Hz at 1 Hz, 10^{-3} nm²/Hz at 1 Hz, and 6×10^{-7} nm²/Hz at 20 Hz), making it one of the quietest short-period seismic stations in the world.

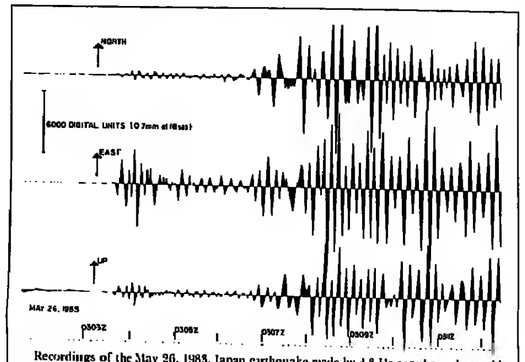
While servicing the system, the HIG scientists recovered 64 days of continuous seismic data recorded between September 13 and November 16, 1982. Earthquakes were recorded about once per hour during that period. A second tape package will record the borehole data between May 26 and July 20, 1983.

Fred Duennebier, project scientist for the ocean sub-bottom seismometer, notes that the R/V *Kana Keoki* was extraordinarily lucky to be on site on the day of a major earthquake (which occurs only about once per year in the North Pacific). Data recording had begun only 8 hours before the quake hit. The instrument was designed with funds from the National Science Foundation and is now funded by the Office of Naval Research.

This news item was contributed by Frederick K. Duennebier, *who is with the Hawaii Institute of Geophysics, University of Hawaii at Manoa, Honolulu, HI 96822.*

EDITOR'S NOTE:

The June 7, 1983, *Eos* incorrectly reported that the subsea seismic station placed earlier this year by the Naval Ocean Research and Development Activity's Marine Seismic System (MSS) office was the first of its kind ("First Subsea Seismic Station," p. 403). The first subsea seismic station was the Hawaii Institute of Geophysics ocean sub-bottom seismometer, which was first placed in 1979 off the coast of Mexico and was successfully placed two other times before the deployment of the MSS instrument.



Recordings of the May 26, 1983, Japan earthquake made by 4.5 Hz geophones located in a hole under the Pacific ocean at 45°55'N, 155°48'E, about 16° from the epicenter. The seismograms were made from filtered digital data band-passed from 0.1 Hz to 0.016 Hz.

Earth Science Ph.D.'s Down 7.3%

If the health of an academic discipline can be measured by the number of doctorates awarded, then there is good news for science and engineering: The total number of Ph.D.'s awarded in 1981 by universities in the United States rose 2.5% (to 17,623) from 1980. Not such good news for the earth sciences, though: The number of doctorates awarded in 1981 in the earth, environmental, and marine sciences (EEMS) dropped 7.3% (to 582), the sharpest decline in all science and engineering categories (see Table 1) according to a special report by the National Science Foundation (NSF).

The number of EEMS doctorates dropped in 1981 to the levels of the early 1970's (in 1972, 604 EEMS Ph.D.'s were awarded). NSF says preliminary data show that the number of science and engineering doctorates granted in 1982 is virtually the same as for 1981; this preliminary data was not broken down into subject areas, however.

TABLE 1. Doctorates Awarded to Men and Women in U. S., 1980 and 1981

Category	1980	1981	Change, %
Earth, environ., & marine sci.	628	582	−7.3
Physical sci.	2,521	2,626	+4.2
(Phys. & astron.)	(983)	(1,015)	(+3.3)
(Chem.)	(1,538)	(1,611)	(+4.7)
Engineering	2,479	2,528	+2.0
Mathematical sci.	962	960	−0.2
Life sci.	4,716	4,783	+1.4
(Biol. sci.)	(3,804)	(3,801)	(−0.1)
(Agricul. sci.)	(912)	(982)	(+7.7)
Social sci.	2,795	2,787	−0.3
Psychology	3,098	3,357	+8.4
Nonsci. & non-eng.	13,817	13,698	−0.9
Total, all fields	31,016	31,319	+1.0

Source: National Science Foundation; percentages have been rounded.

The two fields within EEMS granting the most Ph.D.'s in 1981 were solid earth geophysics and oceanography; the two fields conferring the fewest were geomorphology and glacial geology and atmospheric physics and chemistry (see Table 2). Of the 582 EEMS doctorates, 56 went to women, according to NSF's special report *Science and Engineering Doctorates: 1960–1981*.

Roughly 80% (471) of the 582 EEMS doctorates were U.S. citizens, 17% (100) were non-U.S. students, and 11 students did not specify citizenship. Of the non-U.S. students, 21 were from Europe, 17 from Africa, 11 from East Asia, 10 from West Asia, 9 from Australasia, 7 from Canada, 6 from South Amerira, 5 from Mexico and Central America, and 1 from the region classified as "Cuba and the islands"; the remaining 13 non-U.S. students did not specify their homeland.

Women receiving doctorates in the earth, environmental, and marine sciences in 1981 tended to be younger than their male classmates. And, while women receiving EEMS doctorates in 1981 were younger than those women receiving doctorates in 1980, men receiving doctorates in 1981 tended to be older than those receiving the degree the previous year. The median age of EEMS women doctorates in 1981 was 29.94 years, compared to 30.50 years in 1980. The median age of EEMS men doctorates in 1981 was 31.01 years, compared to 30.87 years in 1980.

For the EEMS doctorate class of 1981, less time elapsed between the baccalaureate degree and the Ph.D. for women than for men, according to NSF's report. For women receiving EEMS Ph.D.'s in 1981, the median time between baccalaureate and advanced degree was 7.33 years; for men it was 8.86 years. In 1980, however, the discrepancy was smaller: the median time was 8.00 years for women and 8.06 years for men. Those receiving doctorates in EEMS in 1981 took longer (median average was 8.27 years) to complete their degrees than any class had in at least 22 years. In addition, this median average is longer than the median average of 7.83 years between baccalaureate and Ph.D. for all science and engineering doctorates. The shortest median time between baccalaureate and Ph.D. among all science and engineering fields was for the physical sciences (6.38 years), especially chemistry (5.99 years); the longest median time was for the social sciences (9.80 years). The median average between the two degrees was longest (12.22 years) for all nonscience and nonengineering doctorates. This figure includes doctorates where no field specialization could be ascertained.

TABLE 2. Earth, Environmental, and Marine Scienre Doctorates Awarded

Field nf Dortorate	1980	1081 Total	Men	Women
Applied genl.	27	21	21	0
Atmospheric dynamics	20	27	26	1
Atmospheric phys. & chem.	19	15	14	1
Atmospheric sci., other	51	31	30	1
Earth sci., general	48	46	42	4
Earth sci., other	21	16	14	2
Environ. sci., general	15	30	27	3
Environ. sci., other	25	24	16	8
Geochem.	51	48	43	5
Geomorphology & glacial geol.	15	13	11	2
Geophys., solid earth	71	72	67	5
Hydrol. & water research	27	21	20	1
Marine sci.	25	30	28	2
Mineral., petrol.	47	30	25	5
Oceanogr.	85	70	63	7
Paleontol.	21	19	18	1
Stratigr., sedimentol.	40	42	35	7
Structural geol.	20	27	26	1
Total	628	582	528	58

Source: National Science Foundation.

Forum

Volcanic Sulfur

Although I may be overly demanding in expecting a member of the *Eos* staff to be familiar with recent articles in AGU journals, I am moved to make a mild protest concerning attribution in the "Volcanic Sulfur Dynamics" news item by Mario E. Godinez (*Eos*, June 14, 1983, p. 411).

Since the news story stated that an important result of the RAVE experiment was to estimate the SO_2 flux from Mount St. Helens on just one day, I must point out that both my research group and USGS scientists have monitored the emissions from Mount St. Helens and estimated SO_2 (and other) fluxes over extended periods of time. Our results, which were based on in situ airborne measurements carried out over a period of a year, include estimates of the flux rates of SO_2, H_2S, H_2O, sulfates, halides, and various other particles, prior to, during, and after the explosive eruption of Mount St. Helens on May 18, 1980 [*Hobbs et al.*, 1982]. The USGS measurements, which are made remotely through use of an airborne correlation spectrometer, also commenced in 1980 and have provided data several times a week since that time [*Gerstenkorn et al.*, 1981]. We have also estimated the fluxes of various materials (including SO_2) from eight other volcanos [*Rhodhe et al.*, 1976; *Stith et al.*, 1978; *Rhodhe*, 1982].

In summarizing (correctly) the contention of *Berresheim and Jaeschke* [1983], the news story states: "Emissions of sulfur during noneruptive phases, *previously neglected by researchers*, are the main source of the volcanic sulfur in the atmosphere" (italics added). We stated in 1978: "A large fraction of both the gaseous sulfur and small particles produced by the 1976 eruption of Saint Augustine were emitted during the milder eruptive periods [intra-eruptive and post-eruptive). As far as tropospheric effects are concerned, perhaps more attention should be paid to these types of emissions, which inject particles and gas into the atmosphere over long periods of time, than to the more sporadic, extremely violent volcanic paroxysms, which generally attract most interest" [*Stith et al.*, 1978]. Concerning Mount St. Helens we wrote: "the long-term post-eruptive emissions [of sulfur gases] dominated the annual inputs" [*Hobbs et al.*, 1982]. Nihil sub sole novi.

Finally, the news story's statement that "effects of sulfuric acid [from volcanic eruptions] are minimal in the troposphere" should not go unchallenged. During our airborne studies of the effluents from Mount St. Helens we collected water samples that had pH's less than unity [*Hobbs et al.*, 1982]. Clearly, the large quantities of sulfur (and other acidic) substances, emitted by some volcanos have the potential to cause significant local and regional impacts in the troposphere, including acid rain. In the case of the Antarctic, it has been estimated that the sulfur emissions from Mount Erebus could contribute as much as ~31% to the total atmospheric sulfate budget of that continent [*Rhodhe*, 1982].

References

Berresheim, H., and W. Jaeschke, The contribution of volcanos to the global atmospheric sulfur budget, *J. Geophys. Res.*, *88*, 3732–3740, 1983.

Casanlevall, T. J., D. A. Johnston, D. M. Harris, W. I. Rose, Jr., L. L. Malinconico, R. E. Stoiber, T. J. Bornhorst, S. N. Williams, L. Woodruff, and J. M. Thompson, SO_2 emission rates at Mount St. Helens from March 29 through December 1980, in *The 1980 Eruptions of Mount St. Helens, Washington*, *U.S. Geol. Surv. Prof. Pap. 1250*, edited by P. W. Lipman and D. R. Mullineaux, 1981.

Hobbs, P. V., J. P. Tuell, D. A. Hegg, L. F. Radke, and M. W. Eltgroth, Particles and gases in the emission from the 1980–81 volcanic eruptions of Mt. St. Helens, *J. Geophys. Res.*, *87*, 11062–11086, 1982.

Radke, L. F., Sulfur and sulfate from Mt. Erebus, *Nature*, *299*, 710–712, 1982.

Radke, L. F., P. V. Hobbs, and J. L. Stith, Airborne measurements of gases and aerosols from volcanic vents on Mt. Baker, *Geophys. Res. Lett.*, *3*, 95–96, 1976.

Smith, J. L., P. V. Hobbs, and L. F. Radke, Airborne particle and gas measurements in the emissions from six volcanos, *J. Geophys. Res.*, *83*, 4009–4017, 1978.

Peter V. Hobbs
Department of Atmospheric Sciences
University of Washington
Seattle, WA 98195

NSF's special report also analyzes the distribution of science and engineering doctorates conferred at the top 100 doctorate-producing institutions in the U.S. Those universities that granted more than 200 EEMS doctorates between 1960 and 1981 inclusive are The Pennsylvania State Univ.; Stanford Univ.; Massachusetts Institute of Technology; the Univ. of Wisconsin—Madison; the Univ. of Washington; Univ. of California (UCI, Los Angeles; Columbia Univ.; the Univ. of Michigan; UC, Berkeley; UC, San Diego; the Univ. of Arizona; Texas A&M Univ.; the Univ. of Illinois; Harvard Univ.; Oregon State University; and Ohio State University. Though also in this top 100 category, Brandeis, American, Temple, and Vanderbilt universities granted no EEMS doctorates 1960–1981, according to NSF.—*BTR*

IUGG Corrections

A paper entitled Geochemical Evolution of the Crust and Mantle by Donald J. DePaolo was inadvertently omitted from the table of contents published with the IUGG Overview of Volcanology, Geochemistry, and Petrology. The overview appeared in *Eos*, August 2, 1983, p. 481.

A paper entitled Accreted Terranes by Amos Nur that was submitted to the Tectonophysics section of the IUGG report was omitted from the July issue of *Reviews of Geophysics and Space Physics*. The paper will appear in the November issue of RGSP as an addendum to the IUGG report. Members of the Tectonophysics section, who received the Tectonophysics report, will receive a reprint of this article.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

For speediest treatment of contributions send three copies of the double-spaced manuscript to one of the editors named below and one copy to AGU.

Editor-in-Chief: A. F. Spilhaus, Jr.; Editors: Marcel Ackerman, Mary P. Anderson, Peter M. Bell (News), Bruce Doe, C. Stewart Gillmor (History), Clyde C. Goad, Arnold L. Gordon, Louis J. Lanzerotti, Robert A. Phinney; Managing Editors: Gregg Forte; Editorial Assistant: Kathleen M. Lafferty; News Writers: Barbara T. Richman; News Intern: Boldizar Dowhaluk; Production Staff: James M. Hebblethwaite, Dae Sung Kim, Patricia Lichtello, Lisa Lichtenstein, Cynthia T. McManigal.

Officers of the Union: James A. Van Allen, President; Charles L. Drake, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

For advertising information, contact Robin E. Little, advertising coordinator, toll free at 800-424-2488 or, in the D.C. area, 462-6903.

Copyright 1983 by the American Geophysical Union. Material in this issue may be photocopied by individual scientists for research or classroom use. Permission is also granted to use short quotes and figures and tables for publication in scientific books and journals. For permission for any other uses, contact the AGU Publications Office.

Views expressed in this publication do not necessarily reflect official positions of the American Geophysical Union unless expressly stated.

Subscription price to members is included in annual dues ($20.00 per year). Information on institutional subscriptions is available on request. Second-class postage paid at Washington, D. C., and at additional mailing offices. *Eos, Transactions, American Geophysical Union* (ISSN 0096-3941) is published weekly by

American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D. C. 20009

Cover. Electron micrographs of microbial cells released from subsurface samples. (*a*) Thin section of cell released by the blending-centrifugation method. Note Gram-negative wall structure and presence of fibrous polysaccharide slime material around cell. (*b*) Thin section of cell released by the blending-centrifugation method. Note Gram-positive cell wall and presence of cross wall (division septum) within cell (CW). (*c*) Negative stain of cell released by the flotation method. Light areas within cell are probably PHB (poly-β-hydroxybutyrate) granules. (*d*) Negative stain of cell released by the flotation method. Note Gram-negative wall structure and that cell appears to be dividing. (Photo submitted by John T. Wilson and James F. McNabb; reprinted by permission of *Ground Water*. Copyright © 1983. All rights reserved.) (See p. 505 for article.)

Eos To List Ph.D. Data

Eos plans to list, regularly, the titles and authors of recently accepted doctoral dissertations in the disciplines of geophysics. The listings will begin with degrees awarded since January 1, 1983.

Faculty members are invited to submit information concerning recently accepted Ph.D. dissertations on stationery of the degree-granting institution above the signature of the faculty advisor or department chairman. The information must include the following four points, which will be published as received:

(1) Title of the dissertation. (If work is not written in English, give the English version of the title, and the name of the original language)
(2) Author
(3) Name of department and institution granting the degree
(4) Month and year degree was awarded

If possible, include the address and telephone number of the degree recipient and information on how a copy of the dissertation or its abstract may be obtained.

Send the information to *Eos*, 2000 Florida Avenue, N.W., Washington, DC 20009.

Recruiting Astronauts

The National Aeronautics and Space Administration (NASA) is recruiting candidates for its 1-year training and evaluation program for space shuttle pilots and mission specialists. Applications will be accepted between October 1 and December 1, 1983; selections will be made by May 1984, and successful candidates will begin their training in July 1984.

Candidates for mission specialist must have a bachelor's degree from an accredited institution in engineering, in the biological or physical sciences, or in mathematics. The degree must be supplemented by at least 3 years of related professional experience. An advanced degree is desirable and may be substituted for all or part of the experience requirement.

Applicants for pilot positions must have a degree in the natural sciences and at least 1,000 hours of pilot-in-command time in high performance jet aircraft.

As part of its affirmative action program, NASA is encouraging applications from qualified women and minority candidates. Current regulations require that U.S. citizens be given preference for all appointments to the program.

Requests for an application package should be addressed to Astronaut Candidate Program, Mail Code AHX, NASA Johnson Space Center, Houston, TX 77058.

Reduced Rates for AIP Journals

The American Institute of Physics (AIP) offers reduced rates for subscriptions of its journals to individual members of affiliated societies. AGU is an AIP-affiliated society. The offer is limited to one subscription per person to each journal.

Rates for 1984 for AGU members are listed below:

	U.S. Member	Non-U.S. Member
Applied Physics Letters	$40	$61
Current Physics Index	65	79
Journal of Applied Physics	80	122
The Journal of Chemical Physics	100	155
Journal of Mathematical Physics	50	64
Journal of Physical and Chemical Reference Data	48	55
The Physics of Fluids	45	68
Physics Today	20	32
Review of Scientific Instruments	35	49

To take advantage of the discount, AGU members should send subscription orders, remittances, and a statement indicating membership status to AIP, 335 East 45th Street, New York, NY 10017.—*BTR*

Geophysicists

The following AGU members are recently deceased:

Hugo B. Fischer, 48. A member of the Hydrology section, he joined AGU in 1967.

Terry J. Shankelford, 37. A member of the Tectonophysics section, he joined AGU in 1985.

Books

Physics of the Jovian Magnetosphere

A. J. Dessler (Ed.), *Cambridge Planet. Sci. Ser.*, Cambridge University Press, New York, xv + 544 pp., 1983, $29.50.

Reviewed by Andrew F. Cheng

Physics of the Jovian Magnetosphere is a comprehensive reference devoted to the latest advances in Jovian magnetosphere physics. Spectacular discoveries by the Pioneer and Voyager spacecraft have led to an explosive development in the subject, with unprecedented coverage in both the popular press and the technical literature. Since 1974 no less than four special issues of *Science*, three special issues of the *Journal of Geophysical Research*, and special issues of *Nature*, *Icarus*, and *Geophysical Research Letters* have been devoted to Jupiter.

Why all the fuss? The Jovian magnetosphere is simply one of the most exotic and interesting objects in the sky.

1. Jupiter's magnetosphere is the most powerful planetary radio source in the solar system, with a spectrum ranging from ~10 kHz, too low to propagate even in the solar wind, to above a GHz.

2. The radio emission at 10–1000 m wavelengths is pulsed at Jupiter's rotation period. The decametric radio emission is also modulated at Io's orbital period. Similar intense, periodic radio emissions are characteristic of the earth and the radio pulsars.

3. An ultraviolet aurora on Jupiter appears to be powered ultimately by the rotation of Jupiter rather than by solar wind interaction as at earth.

4. A sulfur and oxygen ion plasma, with density and temperature similar to the Orion Nebula, is found near Io's orbit. The source of this sulfur and oxygen appears to be Io's volcanos. Sulfur and oxygen ions dominate the mass and charge density of the magnetosphere.

5. Optical and ultraviolet emission lines are observed. Solar resonance lines are detected from sodium and potassium atoms, and collisionally excited forbidden and allowed transitions are observed from sulfur and oxygen ions.

6. A hot heavy ion plasma is found in the outer magnetosphere, composed mainly of sulfur and oxygen ions with typical energies ~95 keV.

7. Jupiter's magnetosphere is the dominant source of less than ~40 MeV electrons in the solar system. It is also known to be a source of soft X rays ~ 0.1–4 keV, energetic neutral particles ~40 keV, and energetic H_3 or H_3^+ molecules above an MeV.

Thus, the Jovian magnetosphere is not only a uniquely interesting object in its own right but, in addition, it has significant implications for many astrophysical problems, such as physics of radio pulsars, HII regions and planetary nebulae, and energetic particle acceleration. No less significant are the implications for problems closer to home, such as the aurora, physics of plasma transport and heating in planetary magnetospheres, and solar-terrestrial interactions.

Many workers in astrophysics, space physics, and geophysics are undoubtedly aware that exciting discoveries have been made about Jupiter but have been waiting for the early results to be collected and digested. These people need wait no longer. Here, in the book *Physics of the Jovian Magnetosphere* is a comprehensive, up-to-date, and authoritative treatment of the latest advances in the field, up to 1982.

The book consists of 12 chapters by 16 authors, with a uniform notation and terminology. The chapters can be read in any order, and each chapter is essentially self-contained. There is no significant duplication of material between chapters, although there is minor overlap with the companion volume *Satellites of Jupiter*.

The first eight chapters give a complete and uniformly excellent review of the observations. These chapters alone are worth the price of the book. The remaining four chapters are theoretical and vary widely in scope, depth, and detail. A unique bonus is the appendix on Jovian coordinate systems, which gives a useful explanation of the many Jovian latitude and longitude conventions. The level of the book, particularly in the observational chapters, is suitable for graduate students and research workers outside the field. Some of the material in the theoretical chapters will be fully appreciated only by experts in plasma theory.

It might have been helpful to provide an introductory overview chapter, which would have given a survey of the main phenomenology, assessed the current status of the field, indicated some directions for future development, and finally discussed implications for other fields in astrophysics and space physics. The individual chapters in the book do provide summary and discussion sections, which discuss some of these topics, but within the context of the separate subfields.

In short, this book is a unique and invaluable resource, which should be considered an essential acquisition for libraries and individuals interested in space plasmas and plasma astrophysics. It is also highly recommended for astrophysicists and space physicists in general.

Andrew F. Cheng is with the Applied Physics Laboratory, The Johns Hopkins University, Laurel, MD 20707.

Satellites of Jupiter

D. Morrison (Ed.), University of Arizona Press, Tucson, Arizona, x + 972 pp., 1982, $49.50

Reviewed by D. J. Stevenson

Future historians of science will look back on the arrivals of the Voyager spacecraft at the Jupiter system in 1979 as very significant events, primarily because of the remarkable diversity of new phenomena discovered on the Galilean satellites. In a short time period, there was almost a doubling of the number of solid "planetary" bodies for which substantial scientific analysis is possible. Scientists were introduced to the novelties of tidally heated bodies and of ice tectonics. From a more fundamental point of view, there is much to be learned about the origin and evolution of planets and their environments from analysis of the satellite systems. Any doubts about the importance of studying planetary satellites must have been dispelled by the Voyager missions.

A meeting was held in Hawaii, May 1980, primarily to present and to discuss the results of the Voyager observations of the Jovian satellites. Arising from the meeting came this new book, another in the excellent *Space Science Series* of volumes published by the University of Arizona Press. Edited by David Morrison with the assistance of Mildred Shapley Matthews, *Satellites of Jupiter* involves 47 collaborating authors, 24 chapters, and is for the most part impressively comprehensive and authoritative. Perhaps inevitably it is also probably the least successful in this series of volumes. Even this is a mild criticism because of the high standards achieved and maintained by these books.

The problem lies in the nature of the subject matter and the circumstances in which this book was produced. Whereas most previous volumes (e.g., *Planetary Satellites*, *Asteroids*) consisted primarily of thoughtful, broad, and integrated reviews of well-established subject matter, authors in *Satellites of Jupiter* were confronted with the task of digesting an enormous data set and presenting overviews of new science in a short period of time. Most of the chapters were finished less than 18

Books (cont. on p. 508)

Books *(cont. from p. 507)*

months after the Voyager encounters; a late chapter or two greatly delayed publication until 1982. As a consequence of the limited time and the novelty of the science, some of the chapters read more like journal papers than review articles. This reviewer also suspects that many of the theoretical interpretations presented will be (or are being) superseded. In fact, most of the fundamental questions posed by the Voyager results remain unanswered. For example, the heat flow of Io is not quantitatively understood (although the tidal heating proposed by Peale et al. is not seriously in doubt), the nature of Europa's surface and outer regions remains enigmatic, no entirely satisfactory explanation yet exists for the remarkable surficial dissimilarity of Ganymede and Callisto, all aspects of the satellite histories (orbital evolution, cratering, internal structure, surface modification, atmospheric) remain controversial, the geochemistry of Io's volcanism is puzzling, and the dynamics of the Io plasma torus remain unclear. Controversy and uncertainty are the lifeblood of science, but the level of ignorance may not be apparent to the reader confronted with 972 pages of information overload.

This book is nevertheless indispensable to the planetary scientist and invaluable to the graduate student or researcher entering (or contemplating) this area. Around 40% of the text deals with Io, an appropriate fraction because of the diversity of phenomena related to it. The other Galilean satellites also receive extensive coverage, and separate chapters are devoted to the rings of Saturn, Amalthea, the outer satellites, and the Io torus. However, most of the chapters deal with physical phenomena rather than with specific bodies.

Notable chapters include S. W. Kieffer's very thorough (although possibly too detailed) effort on the dynamics and thermodynamics of volcanic eruptions; no comparable effort exists anywhere else. The effort by Shoemaker and Wolfe, on cratering time scales, is also a remarkable if somewhat controversial synthesis of existing data and theory. Ostro's chapter on the radar observations of the icy satellites is interesting because it offers a tantalizing glimpse of the nature of the uppermost few meters, potentially very important for understanding the compositional and tectonic evolutions of these bodies. The chapter on atmospheres by Kumar and Hunten is succinct yet thorough, and the geological chapters (Ganymede by Shoemaker et al., Europa by Lucchitta and Soderblom, Io by Shaber) are uniformly well written and good at the descriptive level (but occasionally faltering at the interpretive level).

Typical of the University of Arizona *Space Science Series*, this text is well produced, with a small (but finite) density of typographical errors and a substantial but understandable price in view of the bulk. It could have benefited from stronger editorial control to reduce length, and it also suffers from a small but significant number of poorly reproduced Voyager images or maps (even allowing for the limitations of non-glossy paper). It will remain a very useful text for many years, if only because of the infrequency of deep space missions.

D. J. Stevenson is with the Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

Physique Moleculaire: Physique de l'Atmosphere

C. Camy-Peyret (Ed.), Editions du Centre National de la Recherche Scientifique, Paris, 502 pp., 1982.

Reviewed by Marcel Ackerman

Physique Moleculaire: Physique de l'Atmosphere is a collection of lectures presented at a winter school on the "Application of Molecular Physics to the Atmosphere and to the Environment," organized from December 1–10, 1983, in Montfoulon (Normandy) under the auspices of various French governmental agencies including the National Center for Scientific Research (CNRS), the Center for Nuclear Studies, and the National Center for Space Studies (CNES). This initiative is part of a policy which developed a few years ago in France and is intended to promote interdisciplinary activities in order to foster interdisciplinary research.

Since the early 1970s, several serious questions have been put to the scientific community concerning the possible effects of man's activities on the atmosphere and the likely impact these effects have on the climate. The goal of these lectures was to encourage French scientific communities active in aeronomy, chemical kinetics, meteorology, and spectroscopy to work together on those questions of upper atmosphere-climate relationships, since they offer a typical interdisciplinary character. Most of the 12 lectures are in French, except for two that are in English, and can be divided into two groups: introductions of the structure of the atmosphere, the photochemistry and spectroscopy of atmospheric gases, the radiative transfer and the dynamic modeling of transport phenomena, and photochemistry in the atmosphere and more specialized treatments of remote sensing and in situ techniques used to gather data on the atmosphere from the ground as well as from airborne and space platforms in passive and active modes.

Most of the papers are clearly presented and are well documented with general as well as specific references on the various topics. There are, however, some inhomogeneities among the presentations and redundancies in the presented material. The book will be useful not necessarily only to the French readers, since the book is essentially technical, and it may be a useful introduction to the many very specialized reports and proceedings that have appeared in the last 10 years.

Marcel Ackerman is with the Belgian Space Aeronomy Institute in Uccle, Brussels.

Classified

RATES PER LINE

Positions Wanted: first insertion $1.75, additional insertions $1.50.
Positions Available, Services, Supplies, Courses, and Announcements: first insertion $3.50, additional insertions $2.75.
Student Opportunities: first insertion free, additional insertions $1.50.

There are no discounts or commissions on classified ads. Any type style that is not publisher's choice is charged for at general advertising rates. *Eos* is published weekly on Tuesday. Ads must be received in writing on Monday, 1 week prior to the date of publication.

Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D. C. 20009.

For further information, call toll free 800-424-2488 nr, in the Washington, D. C. area, 462-6903.

POSITIONS AVAILABLE

Research Associate/Petrography-Petrology. To join a research effort aimed at understanding the confinement history of the solar system by mineralogical, chemical, and isotopic studies of tiny inclusions in primitive meteorites. Applicant need not have previous experience with meteorites but should be a superb petrographer, skilled in the use of the SEM and electron probe. Successful candidate will be dedicated, productive, an effective communicator both orally and in writing, and will have Ph.D. in hand. Vacancy expected in mid autumn 1983.

Send resume and names of three references to: L. Grossman, Department of the Geophysical Sciences, University of Chicago, 5734 S. Ellis Avenue, Chicago, IL 60637.

The University of Chicago is an Equal Opportunity/Affirmative Action Employer.

Marine Organic Chemist. Research Associate in the Cooperative Institute of Marine and Atmospheric Sciences, University of Miami and National Oceanic and Atmospheric Administration. Experience in GC-MS-DS and sampling from ships or aircraft desired. M.S. preferred. Contact Chairman Search Committee, D.K. Atwood, NOAA/AOML, 4301 Rickenbacker Causeway, Miami, Florida 33149.

An Equal Opportunity Employer.

PHYSICAL OCEANOGRAPHER/University of Washington. The School of Oceanography invites applications for a tenure-track position in Physical Oceanography. It is anticipated that appointment will be at the Assistant Professor level, but applications for more senior persons are welcome. Applicants should have a strong background in data interpretation and the application of fluid dynamics to modern observational oceanography. Teaching at the undergraduate and beginning graduate level will be emphasized, and the successful candidate will be expected to develop a funded research program involving graduate students. Applicants should send a vita, pertinent reprints, and the names of four references to Dr. Brian T.R. Lewis, Director, School of Oceanography, WB-10, University of Washington, Seattle, WA 98195 tel.: 206-543-6407. The closing date for applications is November 1, 1983.

The University of Washington is an Equal Opportunity/Affirmative Action Employer. Oceanography Advertisement No. 832.

Supervisory Oceanographer/National Ocean Service. Physical Oceanographer, National Ocean Service. A supervisory oceanographer position is immediately available as Chief, Data Processing and Analysis Unit, Circulation Section, Office of Oceanography and Marine Service. The incumbent will supervise seven oceanographers and one physical science technician. Duties include planning circulation surveys conducted by NOAA vessels, processing data collected, and conducting tidal and nontidal analyses. Data collected include current meter, CTD, and meteorological data acquired from the Nation's estuaries and inner continental shelves. Circulation Survey Reports are published for major surveys.

The incumbent will be expected to write technical reports on tidal hydrodynamics and related subjects, present papers at professional conferences, and publish in refereed journals. He/she will serve as an advisor to lower level employees.

At least three years of progressively responsible experience is required and an M.S. degree in physical oceanography, or equivalent, is desired. Applicants with experience with oceanographic instrumentation, analysis of oceanographic data, utilization of statistical methods, and computer techniques will be given priority consideration.

Application deadline is August 28, 1983. A completed Standard Form 171 should be submitted to:

NOAA/National Ocean Service
Ms. Debora C. Hayes
AT/PER15, WSC-1, Rm. 710
6001 Executive Boulevard
Rockville, Maryland 20852

For additional information, contact Charles R. Muirhead, (301) 443-8501. The position is a GM-13, salary range $34,980 to $45,406.

An Equal Opportunity Employer.

RESEARCH ECONOMIC GEOLOGIST

The Department of Mineral Sciences at The American Museum of Natural History is seeking applicants for a curatorial research position in Economic Geology. Major responsibility is to carry out a vigorous research program involving field and laboratory studies on the origin and development of ore deposits anywhere in the world. Close working relationships with other researchers to broaden the scope of the work are encouraged. Involvement with graduate students, if desired, is also possible. Minor responsibilities include some collections development and public programs (eymposium or exhibition). The position offers the freedom and support to carry out major research projects on a large scale, unfettered by major administrative or academic responsibilities.

The Department has excellent laboratory facilities including an automated electron microprobe, X-ray facilities, sample preparation laboratory, photographic and graphic support, and computers. A PhD in Economic Geology is required and the position is open to persons of any rank, with salary negotiable.

Candidates should submit a resume (including a statement of research interest), salary requirements, and the names of three references by October 15, 1983 to:

Dr. Martin Prinz, Search Committee

THE AMERICAN MUSEUM OF NATURAL HISTORY
79th Street at Central Park West, New York, N.Y. 10024
An equal opportunity (M/F/H) affirmative action employer.

Visiting Research Scientist Radio Emission Processes

Applications are invited for a visiting research scientist position in the Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa.

This position is intended to support a multidisciplinary study of planetary, solar and astrophysical radio emission processes funded by the NASA innovative research program. Applicants must have a Ph.D. with a good theoretical background in basic plasma physics and experience in either experimental or theoretical studies of planetary, solar or astrophysical radio emissions. Our intention is to favor established scientists with research experience in this area, although junior scientists with an appropriate background will also be considered. The salary will be commensurate with the experience level. The appointment can be for any period up to one year, with a possibility for extension to a second year, depending on funding constraints.

Send curriculum vitae and a list of three references to:

D. A. Gurnett
Department of Physics and Astronomy
The University of Iowa
Iowa City, Iowa 52242
Telephone 319/353-3527.

The University of Iowa is an affirmative action/equal opportunity employer.

Iowa State University of Science and Technology, Department of Earth Sciences/Research Associate/Electron Microprobe. The Department of Earth Sciences invites applications for a Research Associate position as an electron microprobe specialist. The appointment will be a fully funded, permanent, twelve-month position. Salary will be commensurate with qualifications.

Primary duties are the operation and maintenance of a fully automated microprobe with WDS and EDS capabilities and the supervision of associated laboratory facilities. Additional duties include the instruction of research personnel in instrument operation. Ample opportunities exist for conducting collaborative and independent research involving the microanalysis of geological materials.

Applicants should have a M.S. degree in a science or engineering field, or equivalent experience, and experience with electron beam instrumentation. Persons with a working knowledge of WDS and EDS spectrometers and the accompanying computer operations and experience analyzing geological samples will be preferred applicants.

Application deadline is July 31, 1983. Later applications will be accepted if the position is not filled. Applications should include a complete resume, a statement of background and interests, copies of publications and names of at least three references. Applications should be sent to:

Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science 1
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

Chairman—Department of Geological Sciences, Wright State University. The Department of Geological Sciences, invites applications for the position of chairman, to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic research.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435.

Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Tenure-Track Faculty Position-Geophysics/New Mexico State University. We are seeking a faculty member whose duties will include teaching both undergraduate and graduate level courses, conducting research and supervising graduate level thesis and dissertation research. We are particularly interested in a seismologist, but persons with experience in other geophysical techniques are invited to apply.

Minimum qualifications include an earned doctorate in geophysics or a closely related area and demonstrated research capability. Teaching experience and demonstrated ability to secure research funding are desirable. The position is available in January 1984 for 9-month academic year. Appointment will be at the rank of Assistant or Associate Professor. Salary and academic rank will be dependent on experience and qualifications.

Applications and names, addresses and telephone numbers of at least three references should be submitted to Dr. Chandler Swanberg, Department of Earth Sciences, P.O. Box 3AB, Las Cruces, NM 88003.

Applications received by October 15, 1983 will be given preference.

New Mexico State University is an Affirmative Action/Equal Opportunity Employer.

POSTDOCTORAL POSITION/Washington University. Electrochemist, to study reaction behavior in high temperature (> 1000°C) silicate melts of geochemical interest and direct silicate electrolysis as a smelting technique. Experience in high temperature electrochemistry essential, in silicate electrochemistry strongly preferred. Background in inorganic chemistry desirable. Position available November, 1983, salary $18,000 per year. Send resume, transcript, and names of 2 references to Larry Haskin, Department Earth and Planetary Sciences, Washington University, St. Louis, MO 63130.

An affirmative action, equal opportunity employer.

University of Minnesota Stratigrapher/Sedimentary Petrologist. Tenure-track position starting fall 1984, probably at the Assistant Professor level. The candidate must have a Ph.D. with interest in stratigraphy of sedimentary basins, tectonics and sedimentation, and sedimentary petrology, and will be expected to carry out research and to teach graduate and undergraduate courses in these fields. Please submit resume, academic records, and three letters of recommendation to Dr. Peter J. Hudleston, Department of Geology and Geophysics, 108 Pillsbury Hall, University of Minnesota, Minneapolis, MN 55455 (612) 373-3573.

The University is an Equal Opportunity/Affirmative Action Employer.

Florida International University/Faculty Positions in Geology. The Earth Sciences program at Florida International University is expanding and plans to increase the number of its faculty positions in the next few years. In order to complement existing professional and research strengths, the university invites applications for tenure track positions at the assistant professor level in the following areas of specialization.

1. Stratigraphy/Sedimentology
2. Geophysics/Marine Geology
3. Igneous Petrology/Geochemistry/Economic Geology

Successful applicants must have demonstrated an ability to conduct high-quality teaching and the potential to establish a productive research program in their area of specialty.

Subject to final approval of funding, appointment will begin in August 1983 (deadline for application July 30, 1983) and/or January 1984 (deadline for application November 15, 1983).

Send a resume, brief description of teaching and research interests, transcripts and three letters of recommendation to:

Dr. L. Keller
Department of Physical Sciences
Florida International University
Tamiami Trail, Miami, Florida 33199

Florida International University is a member of the Florida State University system and an affirmative action/equal opportunity employer.

Structural Geologist/University of Maryland. The Department of Geology, University of Maryland at College Park, seeks a structural geologist to fill a tenure-track position at the Assistant Professor level by August, 1984. The applicant should have a commitment toward quality research and can contribute to an rapidly developing M.S. and Ph.D. program as well as an established undergraduate component. Teaching responsibility includes structural geology, tectonics, and applied geophysics.

The College Park campus is located in the Washington metropolitan area close to USGS, Carnegie Institute, Smithsonian Institution, NBS, and U.S. Bureau of Mines. The University computer facilities consist of two Univac 1180 computers, three IBM 370 computers, and several hundred remote terminals. Departmental facilities include basic geophysical exploration equipment, rock preparation equipment, high-temperature and high pressure equipment for mineral synthesis and equilibrium studies. SEM, XRD, AA, and microprobe.

For full consideration, applicants possessing Ph.D. should send a curriculum vitae, three letters of reference, and a description of research to R. L. Nielsen, Chairman, Search Committee, Department of Geology, University of Maryland, College Park, Maryland 20741.

An Equal Opportunity Employer.

Hydrogeologist, Hydrologist, or Water Resources Planner. The Kansas Geological Survey, a division of the University of Kansas, solicits applications for a hydrogeologist, hydrologist, or water resources planner. Permanent, full-time position subject to annual review. Salary Range: $20,016–$30,000 per year, depending on qualifications. Required qualifications: Master's degree in hydrogeology, hydrology, or related water resources field. Course work in theoretical hydrologic modelling and capability to apply these models to different hydrologic and water planning problems in particular areas in Kansas. Preferred qualifications: Ph.D. degree in one of the above fields, and 2–3 years of research experience in water resources related studies.

Freedom to conduct research within the framework of the KGS Geohydrology Section's programs and support of a university environment. Opportunity for graduate study or teaching; and fully funded research opportunities in excellent research facilities.

Contact Personnel Manager, Kansas Geological Survey, 1930 Constant Avenue, Campus West, The University of Kansas, Lawrence, Kansas 66044 (Ph. 913/864-3965) for full position description, or to apply, send resume, college transcripts, list of published research, and three letters of reference. Priority will be given to applications received by October 31, 1983. Applications will be accepted and reviewed every thirty days thereafter until the position is filled.

AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 80 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011

Iowa State University is an equal opportunity/affirmative action employer.

Research Scientist/Space Plasma Physics, University of Iowa. A research position is available in the Department of Physics and Astronomy. The University of Iowa, for theoretical and interpretative studies of waves in space plasmas. Specific emphasis is on theoretical investigations of wave-particle interactions in planetary magnetospheres and in the solar wind. These investigations are to support the interpretation of data being obtained from spacecraft projects such as Dynamics Explorer, International Sun Earth Explorer and Voyager. The applicant must have a Ph.D. with good qualifications in plasma physics theory and should have some experience in the interpretation of space plasma physics data.

Send a resume and the names of three references familiar with the applicant's work to: D.A. Gurnett, Department of Physics and Astronomy, The University of Iowa, Iowa City, Iowa 52242, telephone 319-353-3527.

The University of Iowa is an affirmative action/equal opportunity employer.

University of California/Assistant Researcher. Scripps Institution of Oceanography invites applications for the position of Postgraduate Researcher through Assistant Researcher. Appointment as Assistant Researcher requires a publication record.

The position is in the upper ocean physics group of the Marine Physical Laboratory. Active research areas include air sea interaction, internal wave and mixed layer studies, as well as doppler acoustic sensor design. Candidates should have a Ph.D. in Oceanography, Physics or Engineering as well as experience and a desire to participate in field research. Salary range: $15,036 to $26,800. Send curriculum vitae and names of references to Professor Robert Pinkel, Marine Physical Laboratory, Scripps Institution of Oceanography, UCSD, San Diego, CA 92182. Closing date: August 31, 1983

The University of California, San Diego is an Equal Opportunity Affirmative Action Employer.

Faculty Positions in Physical Oceanography

Department of Oceanography

Naval Postgraduate School

The Department's focus on physical oceanography begun several years ago continues, with a strong emphasis on all elements of ocean prediction. Two or more tenure-earning positions may become available in the next year or so. One is open now. Hiring will most likely be done at the assistant or associate professor level. (Further postdoctoral positions will be available, too.) Successful candidates will have a strong commitment to graduate education and sponsored research.

A PhD in physical oceanography, meteorology, geophysical fluid dynamics, applied mathematics, physics or engineering is required. Ocean dynamicists, ocean and acoustic numerical modelers, and satellite remote sensing scientists are sought.

Research and instructional areas of preference include: numerical ocean circulation modeling, ocean acoustics, upper ocean dynamics, synoptic/mesoscale dynamics, and satellite oceanography. Regional areas of interest include tropical oceanography, polar oceanography, coastal oceanography, and boundary current regimes.

Candidates with theoretical or experimental expertise are of interest. The Department consists of 13 tenure-track faculty, two military faculty, a dozen visiting scientists and research faculty, and a technical and clerical staff of 25. There are in excess of 80 graduate students, largely shared with the Meteorology Department, which is nearly equal in size and which also has interests in air-sea interaction and ocean modeling.

Assets of the Department include a research vessel with ready access to an exciting region of the ocean, free access to an IBM 3033, and proximity to the Fleet Numerical Oceanography Center and the Naval Environmental Prediction Research Facility. Links exist to NORDA, the Naval Oceanographic Office, other Navy labs, and NCAA activities, as well as other academic institutions. Altogether, there are over 100 practicing physical oceanographers and meteorologists in the Monterey area. Finally, the Monterey area has spectacular climate and scenery.

Because more than one position will become available, we will receive applications on a continuing basis. However, for the first position, the initial closing date will be *15 September 1983*. Send a curriculum vitae, statement of professional interests, and names, addresses, and phone numbers of at least three references to:

Prof. Christopher N. K. Mooers, Chairman
Oceanography Department, Code 68
Naval Postgraduate School
Monterey, CA 93940

Telephone (408) 646-2673

The Naval Postgraduate School is an Affirmative Action/Equal Opportunity employer.

The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate levels, and conduct research leading to scholarly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applicants should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211.

Research Positions/Lunar and Planetary Laboratory. The Lunar and Planetary Laboratory at the University of Arizona has research positions open for Research Scientists. Researchers at the Laboratory have access to the University's observatories, a wide range of astronomical instrumentation, a complete collection of planetary images, computers and laboratory facilities. The research ranks in the Laboratory, namely Assistant Research Scientist, Associate Research Scientist, and Research Scientist parallel the tenure track ranks of Assistant, Associate and Full Professor. Salary levels are commensurate with equivalent tenure-track ranks. These are not tenurable and not state-funded positions. Research in these positions will be expected to supply a significant portion or all of their salaries through their grants and contracts.

Applicants should submit a curriculum vita, list of publications, and the names of three references to: November 1, 1983, to: J. Wilkening, Director, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721.

The University of Arizona is an Equal Opportunity, Affirmative Action Employer.

DIRECTOR OF SCIENCE National Undersea Research Program/University of North Carolina at Wilmington. The National Undersea Research Program at the University of North Carolina at Wilmington is a federally funded research and marine science program sponsored by the National Oceanic and Atmospheric Administration (NOAA). The Program is seeking qualified applicants for the position of Director of Science. The Director is responsible for developing the overall program objectives and strategies, as well as for eliciting, reviewing and coordinating marine research proposals. The Director of Science reports administratively to the Program Director. Academic rank and salary shall be commensurate with experience and qualifications. Starting date is October 1, 1983.

Applicants must have a Ph.D. in a marine-oriented discipline and an established research and publication record. A letter of application, a complete resume and at least three current letters of recommendation should be submitted, no later than September 1, 1983, to: Search Committee-Director of Science, Office of the Vice Chancellor for Academic Affairs, University of North Carolina at Wilmington, 601 South College Road, Wilmington, North Carlina 28403-3297.

An Equal Opportunity/Affirmative Action Employer.

Meetings

Announcements

Deep Fault Zone Drilling

Papers are invited for a special session on the scientific and operational aspects of deep drilling in active fault zones that will be held during the 1983 AGU Fall Meeting in San Francisco, December 5–10. The National Academy of Sciences Continental Scientific Drilling Committee supports the session as a forum for gauging the geology community's interest in deep drilling as a tool for advancing knowledge of earthquake mechanics.

A decade of research on active faults, particularly the San Andreas fault, has brought to light a number of issues that may be efficiently addressed by coring into or near a seismically active rupture zone. For instance, it is a matter of long-standing dispute whether the San Andreas fault is in a state of low stress (<100–200 × 10^5 N m^{-2}) as suggested by the observed low heat flow or high stress (>1000 × 10^5 N m^{-2}) as suggested by laboratory studies of rock friction; it is not known if water at seismogenic depths is mobile or confined, plentiful or sparse; the correlation of fault geometry and mineralogy with observable with seismic activity is limited to loose conjectures. However, the cost of a single drillhole is much more than most geoscientific organizations can afford. Therefore, a goal of the session is to help generate a consensus on the importance of such drilling.

The contributions will complement a small number of invited speakers who will address well-established aspects of deep drilling and review the outstanding scientific questions in fault zone properties. Serious contributions on matters such as drillhole location, drill core acquisition in and out of the fault zone proper, and use of the hole for short- and long-term experiments in earthquake mechanics are welcome. Case histories in deep drilling and/or borehole experimentation pertinent to the fault problem would be particularly desirable. Abstracts in standard AGU format should be sent to Peter Leary or Tom Henyey, Department of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0741 (telephone: 213-743-8254 or 213-743-0123). In addition, send the original and two copies of the abstract by September 14 to AGU Fall Meeting, 2000 Florida Avenue, N.W., Washington, DC 20009.

South East Asian Survey Congress

Hong Kong will host the Second South East Asian Survey Congress, scheduled for December 5–9, 1983. The meeting will be divided into three basic categories: land, engineering, and hydrographic surveying; land economy, valuation, and property management; and quantity surveying and building surveying. In addition to the technical sessions, tours to various locations in China are planned.

For additional information, contact the Congress Secretariat, Second South East Asian Survey Congress, 57 Wyndham Street, 1st Floor, Central, Hong Kong (Telex: 72500 HX). The registration deadline is September 30.

Pacific Marine Conference

The first Pacific Conference on Marine Technology (PACON 84) will be held April 24–27, 1984, in Honolulu, Hawaii. This international and interdisciplinary meeting is designed to provide academicians, resource planners, policy analysts, entrepreneurs, and administrators with an opportunity to discuss the economic, legal, political, defense, and sociocultural dimensions of marine resource development and management in the Pacific Basin. Special attention will be paid to the impact of marine technology on the quality of life in this region.

Sessions are planned on ocean energy, maritime recreation, development financing, ocean mining, ocean science and engineering, marine transportation, offshore resource development, fisheries, trade, technology transfer, navigation and positioning, remote sensing, and tsunami detection. Research and industrial exhibits will be on display.

Authors interested in presenting papers at the conference should submit abstracts of approximately 400 words to PACON 84, Center for Engineering Research, University of Hawaii, 2540 Dole Street, Holmes Hall 246, Honolulu, HI 96822.

Meetings *(cont. on p. 510.)*

Meetings *(cont. from p. 509)*

wali at Manoa, Honululu, HI 96822 (telephone: 808-948-7398 or 808-948-7449). The deadline for abstracts is November 15, 1983. Accepted papers will be considered for publication in the conference proceedings.

The Hawaii Section of the Marine Technology Society, with the assistance of 12 other sponsors from government, education, and business, is organizing this meeting.

AWRA Conference

The American Water Resources Association will hold its 20th Annual Water Resources Conference in Washington, D. C., August 13–16, 1984. A symposium on Options for Reefting Water Quality Goals will highlight the activities scheduled for August 15.

Presentations at the conference will reflect three themes: (1) Institutional Aspects of Water Management will address such topics as state–federal relationships, establishing priorities for water resources investments, and the problems of decaying urban water infrastructures; (2) Water Management Technology will deal with analytical methods for analyzing the performance of water resources systems and with innovative and novel approaches to water management; (3) Data, Research, and Assessment needs will deal with research needs to support improved water management, data needs for analyzing system performance, and future directions for assessing the nation's water resources.

The water-quality symposium will consist of two half-day sessions. No technical sessions on the main themes of the conference will be conducted on the day of the symposium. One section of the symposium will deal with surface water quality. Papers addressing this topic should focus on institutional and technical aspects of pollution control from point and nonpoint sources, monitoring for water quality, water quality–quantity relationships, and alternative and innovative technology for pollution abatement. The second section of the symposium will deal with groundwater quality. Papers on this topic may deal with the prevention and cleanup of contaminated underground aquifers, institutional and technical aspects of controlling groundwater pollution, and groundwater and surface water interrelationships.

All abstracts must be submitted (three copies) by November 15, 1983. Abstracts for conference papers should be sent to Warren Viessman, Jr., Department of Environmental Engineering Sciences, University of Florida, A. P. Black Hall, Gainesville, FL 32611 (telephone: 904-392-0834) or Claire Welty, U.S. Environmental Protection Agency, WH-565B, 401 M Street, S.W., Washington, DC 20460 (telephone: 202-382-4806). Abstracts for symposium papers should be submitted to Theodore M. Schad, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, DC 20418 (telephone: 202-334-3088).

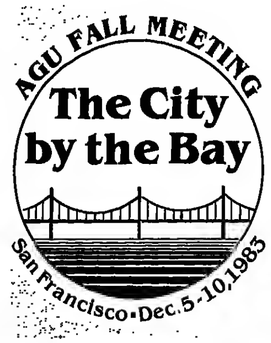
The general chairman of the conference and symposium is Arlene Dietz, U.S. Army Corps of Engineers, Institute for Water Resources, Casey Building, Fort Belvior, VA 22060 (telephone: 202-325-6768).

Hawaii Observatory Diamond Jubilee

The Diamond Jubilee of the Hawaiian Volcano Observatory is being planned for 1987 in Hawaii National Park. Founded in 1912 by Thomas Jaggar and operated by the U.S. Geological Survey (USGS) from 1924–1935 and since 1947, the observatory has pioneered some of the techniques now used at some 25 worldwide volcano observatories that monitor active and potentially active volcanoes.

The international scientific meeting that will mark the observatory's 75th anniversary will focus on volcano monitoring and on reducing volcanic risk. The formal meeting will be interspersed with field trips to volcanic sites on the island of Hawaii.

For more information, contact Robert W. Decker, Scientist in Charge, USGS, Hawaiian Volcano Observatory, Hawaii National Park, HI 96718.



AGU Fall Meeting: Housing and Registration

The 1983 Fall Meeting of the American Geophysical Union will be held in San Francisco, California, December 5–10 at the Cathedral Hill Hotel and the Holiday Inn Golden Gateway Hotel. San Francisco is a dynamic, exciting city, known to the world for its spectacular scenery, fabulous restaurants, cosmopolitan life style, and gentle climate. It is a superb meeting location at any time of the year.

Registration

Everyone who attends the meeting must register. Preregistration (received by November 10) saves you time and money. The fee will be refunded to you if AGU receives written notice of cancelation by November 28. Registration rates are as follows:

	Preregistration	After Nov. 10
Member	$65	$80
Student member	$32	$40
Retired senior member	$32	$40
Nonmember	$90	$105
Student nonmember	$41.50	$50.50

Registration for 1 day only is available at one half the above rates, either in advance or at the meeting. Members of the American Meteorological Society, the American Society of Photogrammetry, the Europeo Geophysical Union, Union Geofisica Mexicana, and the American Congress on Surveying and Mapping may register at the AGU member rates.

The difference between member (or student member) registration and nonmember registration may be applied to AGU membership dues if a completed membership application is received at AGU by February 10, 1984.

To preregister, fill out the registration form, and return it with your payment to AGU by November 10. Your receipt will be included with your preregistration material at the meeting. Preregistrants should pick up their registration material at the registration desk at the Cathedral Hill Hotel. Hours are 8 A.M. to 4 P.M., Monday through Saturday. On Sunday, December 4, registration hours are 5:30 to 7:30 P.M.

Hotel Accommodations

Blocks of rooms ($47 singles, $53 doubles) are being held at the Cathedral Hill, the Holiday Inn Golden Gateway, the Holiday Inn Civic Center, the San Francisca, and the Grosvenor Inn for those attending. Read the housing application, and mail the completed application form to the housing bureau early to ensure reservations at your preferred hotel. *Reservation forms must be sent directly to the Housing Coordinator, AGU Fall Meeting, San Francisco Housing Bureau, P.O. Box 5612, San Francisco, CA 94101.* Do not send housing reservation forms to the hotels.

Reservations must be received by November 1 to be confirmed. Do not write or call AGU for room reservations.

Free parking is available only to registered guests of each hotel as indicated.

Scientific Sessions

The Call for Papers, including specifications for abstracts, was published in the June 28 and July 26 issues of *Eos*. The program summary will be published in the October 18 *Eos*. The preliminary program along with the abstracts will be published in the November 8 *Eos*. The final program, with presentation times, will be distributed at the meeting. Scientific sessions will be held at the Cathedral Hill and the Holiday Inn Golden Gateway hotels only.

New Special Sessions

Atmospheric Sciences (A)

Thunderstorm Dynamics and Electricity
Lightning
Cooperative Convective Precipitation Experiment (CCOPE)
El Niño 1982–1983 (cosponsored with O)

Ocean Sciences (O)

CODE/SUPER-CODE/OPUS
Subseabed Disposal of Nuclear Waste: Site Assessment
El Niño in the California Current System

Tectonophysics (T)

Deep Fault Zone Drilling
Paleomagnetism and West Coast Tectonics
Problem Solving with Rock Magnetic Techniques: A Workshop

Session Highlights

See the June 28 and July 26 issues of *Eos* for descriptions of other special sessions.

Paleomagnetism and West Coast Tectonics (GP)

Because there is much to be learned from setting one's results in a larger framework, this session will encompass any part of the western Americas from Point Barrow to Cape Horn and from well inboard to well outboard of the present continental margin. The primary focus will be on the kinematic histories of terranes and plates as demonstrated by paleomagnetic evidence (e.g., plate motion models, regional geologic studies, etc.) that provide important constraints on large-scale displacement and in situ rotation of allochthonous terranes.

Problem Solving with Rock Magnetic Techniques: A Workshop (GP)

The purpose of this session will be to present special applications of rock magnetism to problems in a broad range of fields such as geophysics, geology, planetary science, and biology. A wide variety of papers is encouraged. Examples of topics to be addressed include conventional applications of rock magnetism to paleomagnetism; interesting examples of recognition of CRM and VRM; useful information stored in secondary components of NRM; applications of magnetic anisotropy to fabric analyses and tectonics; solving problems encountered in determining paleointensity; and applications to biomagnetic phenomena.

Oceanographic and Geodetic Research With Altimetry Measurements (O and G)

Papers discussing current research in this area are solicited. Overviews and updates of future satellite altimeter missions (e.g., GEOSAT and TOPEX) will be presented in invited talks. Abstracts, in standard AGU format, should be sent by August 31 to C. J. Koblinsky, Mail Code A-030, Scripps Institution of Oceanography, La Jolla, CA 92093 (telephone: 619-452-4775). In addition, send the original and two copies of the abstract by September 14 to AGU Fall Meeting, 2000 Florida Avenue, N.W., Washington, DC 20009.

El Niño in the California Current System (O)

Observations of the California Current during 1982–1983 show several anomalous conditions: warm sea surface temperatures, major depression of the thermocline, and pronounced subsurface warming relative to historical data. The anomalies are coincident with the 1982–1983 equatorial El Niño. This session encourages both observational and theoretical papers which document the strength of the 1982–1983 event and interpret the observations in terms of either direct or remote large-scale air–sea interactions. Results that show the effect of these anomalous, large-scale processes on small scale or mesoscale processes in the California Current also are encouraged. For more information, contact session chairman J. J. Simpson, Scripps Institution of Oceanography, A-030, La Jolla, CA 92093. Send the original and two copies of the abstract by September 14 to AGU Fall Meeting, 2000 Florida Avenue, N.W., Washington, DC 20009.

Meetings *(cont. on p. 512)*

FIELD TRIP FORM

I wish to attend the Franciscan Nunu-terrane field trip on Sunday, December 4. My check for $25 is enclosed.

In case I am not among the first 40:

☐ I wish to be put on the waiting list. (If you don't go, money will be returned on the day of the trip.)

☐ I wish my money returned.

Signature _____ Print Name _____

Date _____

Address _____

_____

Telephone _____

Mail form to: M. C. Blake, Jr., Mail Stop 75, U.S. Geologienl Survey, 345 Middlefield Road, Menlo Park, CA 94025

RETURN THIS FORM WITH PAYMENT TO:

Meeting Registration
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

PLEASE PRINT CLEARLY

NAME ON BADGE

_____

AFFILIATION

_____

MAILING ADDRESS _____

_____

_____

Telephone # _____

HOTEL

_____

Days you plan to attend
Please check the appropriate box(es)
☐ Dec. 5 ☐ Dec. 6 ☐ Dec. 7
☐ Dec. 8 ☐ Dec. 9 ☐ Dec. 10

Please check appropriate box.
Members of the cooperating societies may register at AGU member rates
Member badges are blue on white
Nonmember badges are red on white
☐ Member AGU ☐ Nonmember
☐ Member cooperating society
☐ AMS-American Meteorological Society
☐ ASP-American Society of Photogrammetry
☐ ACSM-American Congress on Surveying and Mapping
☐ EGU-European Geophysical Union
☐ UGM-Union Geofisica Mexicana

Nonmembers

The difference between member (or student member) registration and nonmember registration may be applied to AGU dues if a completed membership application is received at AOU by February 10, 1984.

Preregistrants

Your receipt will be in your preregistration packet. The registration fee will be refunded if written notice of cancelation is received in the AOU office by November 28. The program and meeting abstracts will appear in the November 8 issue of *Eos*.

AGU 1983 FALL MEETING
DECEMBER 5-10
San Francisco, California

REGISTRATION FORM

Deadline for Receipt of Preregistration NOVEMBER 10, 1983

(rates applicable only if received by November 10 with payment)

	More than one day	One day
MEMBER	☐ $65	☐ $32.50
STUDENT MEMBER	☐ $32	☐ $16
RETIRED SENIOR MEMBER	☐ $32	☐ $16
NONMEMBER	☐ $90	☐ $45
STUDENT NONMEMBER	☐ $41.50	☐ $20.75

SECTION LUNCHEONS/DINNER

Circle section and indicate number of tickets. All lunches begin at noon. SPR dinner begins at 6:30 P.M.

____ Planetology/Volcanology, Geochemistry and Petrology, Tuesday, $9
____ Seismology/Tectonophysics, Tuesday, $5
____ Geomagnetism and Paleomagnetism, Wednesday, $5
____ Hydrology, Wednesday, $9
____ Ocean Sciences, Wednesday, $9
____ Solar-Planetary Relationships, Wednesday, $20 (dinner)
____ Atmospheric Sciences, Thursday, $9
____ Geodesy, Thursday, $9

Total Enclosed $ _____
(All orders must be accompanied by payment or credit card information. Make check payable to AGU.)

Charge to: ☐ American Express ☐ Visa ☐ Master Card

Card Number _____

Master Card Interbank No. _____

Expiration Date _____

Signature _____

Office Use
Code
Check No.

HOTEL ACCOMMODATIONS

PARTICIPATING HOTELS

Cathedral Hill Hotel
Van Ness at Geary Street
(900) 227-4730

Holiday Inn Golden Gateway
1500 Van Ness Avenue
(415) 441-4000

Grosvenor Inn
Van Ness and Geary Street
(415) 673-7411

Holiday Inn Civic Center
50 8th Street
(415) 626-6103

San Franciscan Hotel
1231 Market Street
(415) 626-8000

ROOM RATES FOR ALL HOTELS

Single $47
Double $53
Twin $53

Suites available upon request

PARKING: **Cathedral Hill Hotel**; free to registered guest
Holiday Inn Golden Gateway; free to registered guest
San Franciscan Hotel; free to registered guest

All hotel reservations must be made on the housing form by November 1, 1983. No telephone requests will be accepted. Confirmations will be mailed directly to registrants by the individual hotels. After confirmation has been received, changes and cancelations should be made directly to the hotel.

Mail your completed form directly to:

Housing Coordinator
AGU Fall Meeting
San Francisco Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

American Geophysical Union
1983 FALL MEETING

HOUSING REGISTRATION FORM

READ CAREFULLY and RETURN FORM DIRECTLY TO THE SAN FRANCISCO HOUSING BUREAU AT THE FOLLOWING ADDRESS:

Housing Coordinator
AGU Fall Meeting
SF Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

Please print or type all information, abbreviating as necessary. Confirmation will be sent by the hotel to the individual named in Part 1. If more than one room is required, this form may be photocopied.

Part I

REQUESTOR
Last Name First

Name of Company or Firm

Street Address or P.O. Box Number

City State/Prov. Zip-U.S.A.

Country Telephone Number

Part II

INSTRUCTIONS: Select *THREE* Hotels of your choice from the list of participating facilities, then enter the name on the lines below.

First Choice _____ Second Choice _____ Third Choice _____

NOTE: Rooms are assigned on a "First Come, First Served" order, and if none of your choices are available, another facility will be assigned based on a referral system. A cut-off date is in effect; your application may not be processed if received after 14 days prior to your arrival date. **AGU housing registration deadline is November 1.**

Part III

INSTRUCTIONS: 1. Select type of room desired with arrival and departure dates.
2. *PRINT* or *TYPE* names of *ALL* persons occupying room.
3. If more than two persons share a room, check twin and the hotel will assign two double beds.

CHECK ONE		Guest Names (Last name first)
☐ SINGLE (Room with one bed one person)	Arrival Date _____	1. _____
☐ DOUBLE (Room with one bed two persons)	Arrival Time _____ AM/PM	2. _____
☐ TWIN (Room with two beds two persons)	Departure Time _____	3. _____
☐ EXTRA PERSON		4. _____

IMPORTANT NOTE: Hotel MAY require a deposit or some other form of guaranteed arrival. If so, instructions will be on your confirmation form.